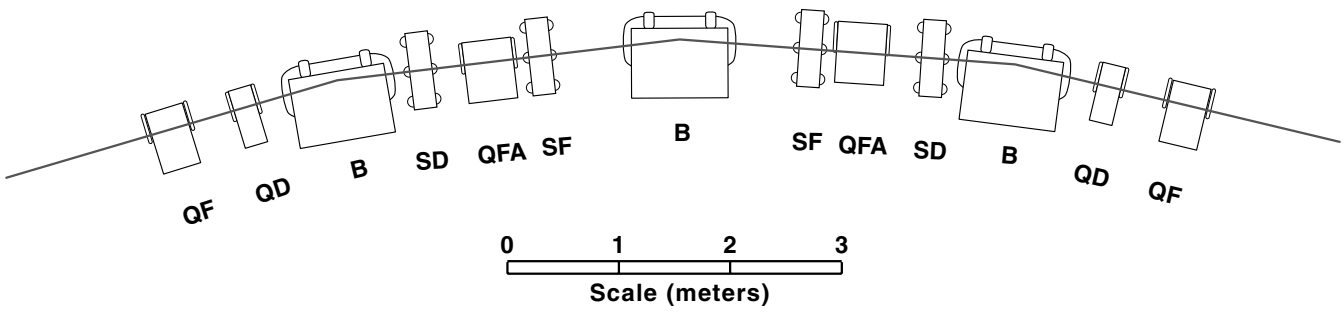
A Third-Generation, Low-Emittance Storage Ring for High Brightness

Berkeley Lab • University of California

Storage-Ring Overview

Energy Range (GeV)	Current (mA)	Beam Size (μm, rms)	Pulse Length (ps, FWHM)	Pulse Interval (ns)	Refill Interval (hr)
1–1.9	400 (Multibunch)	200 (h) × 20 (v) (Straight section)	35 (Multibunch @ 1.5 GeV)	2 (Multibunch)	5–6 (Multibunch)
	2 × 20 (Two bunch)	112 (h) × 12 (v) (Center bend)	35–80 (Two bunch @ 1.5 GeV)	328 (Two bunch)	~2.5 (Two bunch)



One superperiod of the triple-bend achromat lattice of the ALS storage ring showing bend magnets (B), quadrupoles (QFA, QF, and QD), and sextupoles (SF and SD).

One of the first third-generation synchrotron light sources, the ALS comprises an electron-accelerator complex (a 50-MeV linac, a 1.5-GeV booster synchrotron, and a low-emittance storage ring), experimental facilities (beamlines and experimental stations), and a building to house them.

The storage ring is based on a triple-bend achromat lattice with three bend magnets in each of twelve curved sections. The first and second bend magnets in each arc have ports for VUV and soft x rays; the third magnet has a port for infrared radiation. The arcs connect twelve 5-m-long straight sections. One of these is the injection straight where electrons from the booster synchrotron enter the storage ring, and one is occupied by two rf cavities that maintain the electron beam at constant energy (or accelerate it to reach beam energies above 1.5 GeV). Ten straight sections are available for insertion devices. (See the data sheet "Current and Planned Beamlines for Users Through 2002" for beamline status.)

The storage-ring beam energy is continuously variable between 1.0 GeV and 1.9 GeV, but almost all operation is now at either 1.5 GeV (the nominal design energy with the highest brightness) or 1.9 GeV (for extended spectral coverage).

Designed to generate synchrotron radiation of the highest brightness, the ALS storage ring is characterized by a very low emittance, which results in an electron beam with a smaller cross-sectional area and divergence than in older machines. To obtain the lowest possible beam size, a feedback system is used that combats a beam-enlarging instability. With the

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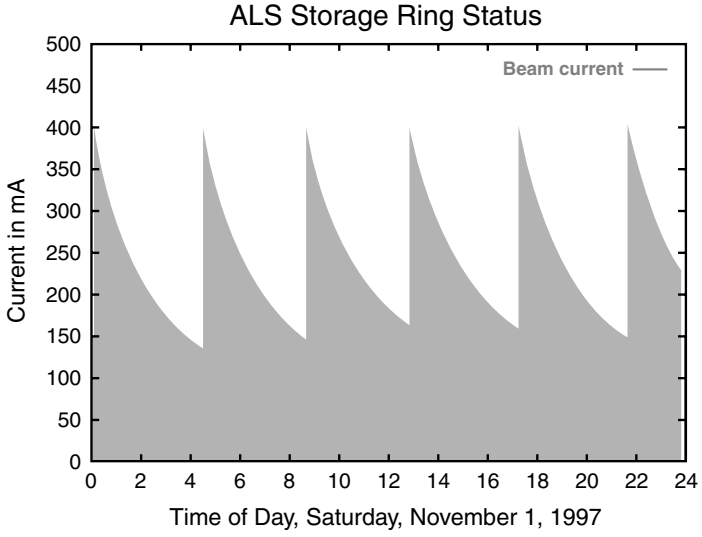
feedback system on, the horizontal emittance is 4 nm·rad at 1.5 GeV and 6.4 nm·rad at 1.9 GeV. The vertical emittance is nominally 1% of the horizontal. However, at 1.5 GeV, to increase the lifetime, the vertical emittance is increased by means of skew quadrupole magnets to about 3% of the horizontal.

The electron beam in the storage ring can comprise anywhere from 1 to 328 bunches. The most common mode is the multibunch mode. This mode currently contains 287 bunches, each lasting 35 ps (FWHM) at 1.5 GeV and separated by 2 ns. With a maximum beam current of 400 mA, the multibunch mode accommodates the needs of most users. A two-bunch mode with a maximum current of 20 mA per bunch and a separation between pulses of 328 ns is available for experimenters who need long spaces between pulses for "timing" experiments, such as time-of-flight spectroscopy or pump-probe measurements. Owing to the higher current per bunch in this mode, however, the bunch length increases to as much as 80 ps. A so-called "camshaft" multibunch mode also serves the needs of many timing-mode users without inconveniencing others with a low current. In this mode, one bunch is filled with significantly more electrons than the other bunches and has several empty buckets on each side.

Owing primarily to intrabunch collisions (Touschek scattering), the current decays with time at a rate primarily dependent on the instantaneous value of the current and the beam size. At the nominal pressure in the storage-ring vacuum chamber, scattering between electrons and residual gas molecules is not important. The typical time between refills is 4 hours for the multibunch mode of operation with the beam-feedback system activated and 2.5 hours for the two-bunch mode.

The ALS publishes a long-term operating schedule outlining the beam energy and filling pattern for each eight-hour user shift. A more detailed weekly schedule is also issued. This information, together with the actual operational status of the storage ring (as well as archived history) is available on the Web at *www-als.lbl.gov/als/als_ops/ops_home.html*. Requests for specific operating conditions should be made in advance to the Operations Group Leader. ■



Typical ALS operations history showing current versus time of day for multibunch fills with feedback.

Contact Information.

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Storage Ring

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